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TITLE: Development of an Integrated Team Training Design and Assessment Architecture to Support Adaptability in Healthcare Teams

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14. ABSTRACT

Purpose and Scope: It is the purpose of this project to optimize adaptability and mitigate teamwork-related threats to patient safety by addressing key methodological and conceptual gaps in healthcare simulation-based team training. The investigators are developing the necessary conceptual framework and team performance assessment mechanisms to support training systems that improve adaptability and performance in trauma teams.

Aim 1a. Develop a team training design architecture to support simulation-based training/assessment systems capable of developing adaptive expertise in healthcare teams

Aim 1b. Develop evidence-based guidelines and recommendations for the development of embedded, adaptive feedback and performance assessments

Aim 2. Develop and refine a predictive model of trauma team performance and outcomes for use in an adaptive guidance system

Major Findings: The investigators performed a four-step process to develop a unified team training design architecture and supporting conceptual framework. They identified key training design principles and recommendations for the development and implementation of embedded, adaptive feedback and performance assessment. The investigators also initiated work designing a Bayesian Belief Network (BBN)-based model of trauma team performance and outcomes. This work (Aim 2) is the focus of Year 2.

Impact: The provision of emergency care in a combat situation mandates well-developed adaptive expertise, making this work relevant to military healthcare. Our work provides a roadmap and mechanism for future work in a multitude of healthcare teams and settings.

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<tr><td colspan="6">15. SUBJECT TERMS
Military healthcare team; Trauma teams; Team training; Teamwork; Adaptive performance; Leadership; Simulation; Modeling; Bayesian belief networks (BBN)</td></tr>
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1. INTRODUCTION

Health care team performance is critical to the provision of safe, efficient, and effective care. Team adaptability is necessary for effective team performance and is especially critical for trauma teams, whose members must anticipate change and rapidly coordinate effective responses. Teams that are not highly adaptive function in a reactive mode that is fraught with potential safety and error risks. Rigorously designed computer-based simulation systems have the potential to support active learning experiences and improve adaptability and performance in individuals and teams. This technology has the potential to link individuals, teams, and units together for the purpose of engaging in common training exercises. However, without the proper supporting design elements, these simulations are ineffective and inefficient training tools. Current health care team training models and strategies do not specifically leverage the training design elements and assessment-driven feedback mechanisms that improve team performance in highly dynamic settings. The **goal of the proposed project is to improve health care team adaptability and patient safety** by providing the necessary conceptual framework and assessment mechanism to support the design and implementation of highly effective simulation-based team training with embedded, adaptive guidance. This project is organized into the following Aims:

Aim 1a. Develop a team training design architecture to support simulation-based training /assessment systems capable of developing adaptive expertise in healthcare teams

Aim 1b. Develop evidence-based guidelines and recommendations for the development of embedded, adaptive feedback and performance assessments

Aim 2. Develop and refine a predictive model of trauma team performance and outcomes for use in an adaptive guidance/feedback system

The **outcomes** from this research will provide the fundamental knowledge, both conceptual and operational, to support the development of simulation-based team training systems with embedded guidance. Our **long-term goal** is to optimize health care team performance and adaptability through rigorous training design.

2. KEYWORDS AND ABBREVIATIONS

Healthcare team
Trauma
Trauma teams
Team training
Teamwork
Adaptability
Adaptive performance
Leadership
Simulation
Modeling
Bayesian belief networks (BBN)

3. ACCOMPLISHMENTS

3a. What were the major goals of the project (organized by Aim)?

Aim 1a. Develop a team training design architecture to support simulation-based training/assessment systems capable of developing adaptive expertise in health care teams

Aim 1b. Develop evidence-based guidelines and recommendations for the development of embedded, adaptive feedback and performance assessments

The primary outcome of Aim 1a is a conceptually and methodologically sound training design architecture that supports the development and integration of team training and automated assessment technologies in simulation environments. The primary outcome of Aim 1b is a set of best practice guidelines and recommendations for the design and incorporation of adaptive, embedded feedback (guidance) into simulation-based team training. The tasks, timeline, and status of each step associated with Aims 1a and 1b are summarized in the table below.

Aims 1a and 1b: Major Goals and Tasks

Aims 1a and 1b Tasks	Timeline (Months)	Status
Task 1: Project Start-up		
Establish subcontracts to enable purchasing.	0 – 3	**COMPLETED**
Local/Site IRB application submissions	0 – 3	All IRB submissions have been completed and the project has been awarded exempt status by each institution. **COMPLETED**
Assembly of subject matter expert panel	0 – 3	Subject matter experts have been invited and the panel now contains experts from emergency medicine, simulation, trauma surgery, and nursing. Individuals were chosen for their expertise and to ensure geographical representation. **COMPLETED**
Human Research Protection Office IRB	3	The HRPO has granted exempt status. **COMPLETED**
Milestone(s) Achieved: 1. Project infrastructure in place 2. Local/Site IRB and HRPO Approval	6	**100% COMPLETED**
Task 2: Identify constructs of interest		
Literature search strategy	0 – 3	Search strategy within healthcare literature, trauma performance literature, trauma outcomes literature, and team science has been defined. **COMPLETED**
Review of identified manuscripts and literature	0 – 6	The review of relevant literature (healthcare and team science) to inform the conceptual model and framework of adaptive performance has been completed. **COMPLETED**
Milestone(s) Achieved: 1. Identification of individual and team performance constructs for the conceptual framework and training architecture	6	We identified relevant individual and team constructs and designed a draft framework. We anticipate continuing to revisit this framework as model testing occurs (Aim 2). We show this as an ongoing milestone nearly complete. **On time, 99% completed**
Task 3: Determine relevant variables and relationships		
Develop nomological net among constructs identified in Task 2	3 – 9	We have identified key relationships between processes and variables critical for team adaptability. **COMPLETED**
Subject matter expert review of variables and relationships	6 – 9	Trauma care and military experts reviewed the components of our adaptability model. Modifications included the addition of cognitive adaptability and diagnostic process as a key component of trauma team adaptive capacity. **COMPLETED**
Milestone(s) Achieved: 1. Identification of individual and team performance constructs for the conceptual framework and training architecture	9	**100% COMPLETED**
Task 4: Identify appropriate level of constructs and variables		
Identification of appropriate levels for constructs, relationships, and outcomes identified in Task 3	6 – 9	Literature reviews and subject matter expert opinion was used to choose and adapt a model of individual, team, and system-level measurement necessary to guide the development and

		implementation of effective team training. **COMPLETED.**
Milestone(s) Achieved: 1. Multilevel framework of healthcare team training performance	9	We identified relevant individual and team constructs and designed a draft framework. We anticipate continuing to revisit this framework as model testing occurs; therefore will reflect this as an ongoing milestone nearly complete. **On time, 99% completed**
Task 5: Identify appropriate outcome measures and mechanisms		
Construct framework for provision of adaptive guidance during simulation-based team training	6 – 9	Relevant feedback mechanisms and designs have been identified and a draft framework has been designed. **COMPLETED.**
Subject matter expert review of feedback framework	9 – 12	In process. We currently have our military, external team science, and external emergency medicine subject matter experts reviewing the structure of our feedback framework to ensure the framework is compatible with current military training efforts and reflective of current team science recommendations. Our military expert and collaborator, Jay Baker, MD, took a new assignment. We have since identified a new collaborator from Madigan Army Medical Center, Capt. Lindsay Grubish, DO, to serve as a co-investigator on the project (see Changes / Problems). We are in the process of obtaining appropriate approval and a letter of support. This task is expected to be completed within the next 30 – 60 days.
Milestone(s) Achieved: 1. Integrated team training design architecture 2. Evidence-based guidelines and recommendations for the provision of embedded, adaptive guidance	12	**In process, 90% completed. Anticipate full completion within the next quarter.**
Task 6: Identify appropriate outcome measures and mechanisms		
Construct framework for provision of adaptive guidance during simulation-based team training	6 – 9	Relevant feedback mechanisms and designs have been identified and a draft framework has been designed. **COMPLETED.**
Subject matter expert review of feedback framework	9 – 12	In process. We currently have our military, external team science, and external emergency medicine subject matter experts reviewing the structure of our feedback framework to ensure the framework is compatible with current military training efforts and reflective of current team science recommendations. Our military expert and collaborator, Jay Baker, MD, took a new assignment. We have since identified a new collaborator from Madigan Army Medical Center, Capt. Lindsay Grubish, DO, to serve as a co-investigator on the project (see Changes / Problems). We are in the process of obtaining appropriate approval and a letter of support. This task is expected to be completed within the next 30 – 60 days.
Milestone(s) Achieved: 3. Integrated team training design architecture 4. Evidence-based guidelines and recommendations for the provision of embedded, adaptive guidance	12	**In process, 90% completed. Anticipate full completion within the next quarter.**

Aim 2. Develop and refine a predictive model of trauma team performance and outcomes for use in an adaptive guidance/feedback system

The primary outcome from Aim 2 is a predictive trauma team performance assessment tool that generalizes to teams of varying expertise levels and across civilian and military contexts and is capable of supporting embedded, adaptive guidance during simulation-based team training. Our approach examines the use of Bayesian Belief Networks (BBNs) to support the provision of adaptive, embedded guidance that facilitates development of adaptive expertise and trauma team performance. We utilize existing simulation-based trauma team performance data to construct a BBN that models the relationships between key individual and team characteristics, behavioral outcomes, and patient care events in a previously well-defined and validated simulated scenario. The model will leverage the probabilistic interdependencies among these variables to enable educators and/or learners to assess the likelihood of critical team/patient outcomes in the simulated environment. We then incorporate the design architecture conceptual foundations developed in Aims 1a&b to guide the transformation of predictive model data into an adaptive guidance tool. The tasks, timeline, and status of each step associated with Aim 2 are summarized in the table below.

Aim 2: Major Goals and Tasks

SPECIFIC AIM 2	Timeline (Months)	Status
Task 1: Collection of prospective simulation data		
Subject recruitment	4 – 6	**Completed, 100% completed**
Execute trauma resuscitation simulations	4 – 6	Due to resident scheduling, trauma resuscitation simulations began 04/2016. We were unable to complete all simulations prior to the change in academic year. **We anticipate completion Oct 30, 2016**. **Delayed, 80% completed**
Train and calibrate raters	6	Rater training has been designed to code new simulations. Existing trauma videos have been coded, with excellent inter-rater reliability. We anticipate refresher training periodically. **COMPLETED**
Code videos of simulated resuscitations using patient care and teamwork measures	6 – 12	Simulation video processing has slightly delayed the initiation of coding; coding is now underway. We anticipate completion at the end of Q6. To ensure timely completion, we have hired additional video processors and purchased additional storage to allow more rapid, efficient video processing. **Delayed, 50% complete, (Q5 completion planned)**
Transform data into appropriate categorical structure for BBN	9 – 12	Using subject matter input, we are transforming existing data into a categorical structure to facilitate BBN development. This is required to execute BBN modeling and requires the input of clinical experts. The overall structure of the BBN has been determined (Figure 5). Data transformation steps have been initiated. This process requires multiple iterations and testing. This subtask is slightly delayed, we expect to be complete by the end of Q5. **Delayed, 20% completed, (Q5 completion planned)**
Milestone(s) Achieved: 1. Team data set of teamwork and patient care performance during trauma resuscitation simulation	12	**Delayed, 50% completed, (Q5 completion planned)**
Task 2: Identify and define variables (nodes) for inclusion in team assessment model		
Examination of conceptual frameworks and literature review from Aims 1a and 1b	9 – 12	This work is in process and nearly complete. We are finalizing the review of feedback principles to make final decisions regarding when the BBN will be designed to provide information to learners and instructors and in what format the feedback should be delivered. This subtask is delayed by approximately 1 month. **Delayed, 80% completed, (Q5 completion planned)**

Evaluation of existing experimental dataset to identify and extract variables of interest	9 – 12	We have initiated review of existing datasets for candidate variables appropriate for inclusion in the BBN. Transforming the existing dataset required more work than anticipated. This subtask is therefore delayed. We anticipate completion no later than Q6. As this step is occurring simultaneously with Task 3, we do not anticipate being more than 3 months delayed overall. **Delayed, 20% completed, (Q6 completion planned)**
Milestone(s) Achieved: 1. Identification of observable measures and latent constructs to be incorporated into the BBN	12	**Delayed, 50% completed, (Q6 completion planned)**
Task 3: Design the structure for the prototype BBN team assessment system		
Identify appropriate and parsimonious candidates for the causal structure among the variables	12 – 15	Planned, 0% completed
Subject matter expert review of variable relationships	12 – 15	Planned, 0% completed
Milestone(s) Achieved: 1. Identification of multiple candidate BBNs for the observed variables	15	Planned, 0% completed
Task 4: Generate initial probability tables for BBN team assessment system		
Transform data into appropriate categorical structure	12 – 15	Planned, 0% completed
Explore different learning algorithms	15 – 18	Planned, 0% completed
Assess BBN fit	15 – 18	Planned, 0% completed
Generate conditional dependencies for unavailable data	15 – 18	Planned, 0% completed
Milestone(s) Achieved: 1. Functional prototype BBN team assessment system	18	Planned, 0% completed
Task 5: BBN team assessment system calibration		
Transform prospective data into appropriate categorical structure for BBN	12 – 15	Planned, 0% completed
Use prospectively collected data to calibrate BBN	18 – 21	Planned, 0% completed
Use subject matter experts and empirical data from the literature review in Aim 1a to adapt the BBN as needed	18 – 21	Planned, 0% completed
Milestone(s) Achieved: 1. Functional, generalizable prototype BBN trauma team assessment system	21	Planned, 0% completed
Task 6: Report writing and dissemination		
Prepare final report and manuscripts	21 – 24	Planned, 0% completed
Submit final reports and manuscripts	24	Planned, 0% completed
Milestone(s) Achieved: 1. Dissemination of methodological approach and empiric findings	24	Planned, 0% completed

BBN = Bayesian Belief Network

3b. What was accomplished under these goals (organized by Aim)?

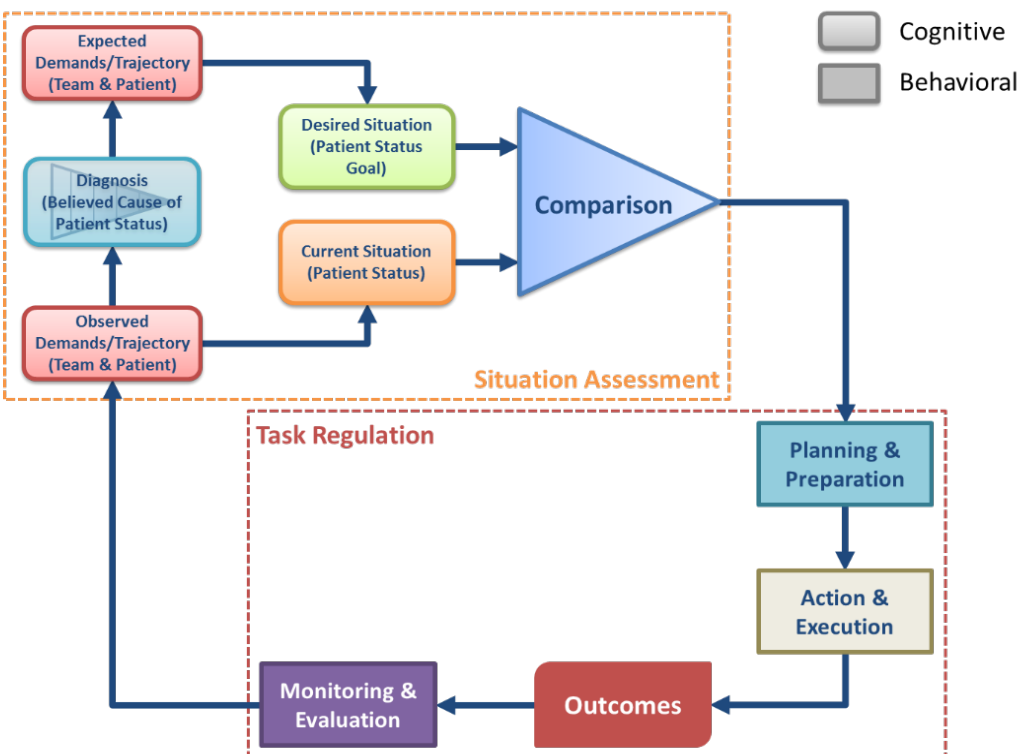
Aim 1a. Develop a team training design architecture to support simulation-based training/assessment systems capable of developing adaptive expertise in health care teams

Aim 1b. Develop evidence-based guidelines and recommendations for the development of embedded, adaptive feedback and performance assessments

Data Collection: A robust literature review is critical to the development of a comprehensive health care team training design architecture. We conducted an extensive literature review, both within healthcare and team science literature to identify key components of team performance adaptability. We focused specifically on identifying the individual and team processes that drive adaptive behaviors, as well as possible metrics that would indicate adaptability at individual and team levels. We then convened a multidisciplinary group of nurses and physicians from both civilian and military health care settings to provide expertise and insight into how these adaptive behaviors translate to the health care setting, and how they might develop over different levels of expertise. Finally, we observed both simulated and actual trauma team performance to augment our data and further our understanding of how adaptive performance unfolds during highly complex clinical activities. This information was then used to inform the identification of **key conceptual models** described below.

Defining Adaptive Performance in Trauma Teams: We used the literature review and subject matter expert review described above to identify all individual and team-performance concepts and constructs that are relevant to training, assessing, and supporting adaptive trauma team performance. Our initial adaptive performance model did not reflect the need for trauma teams to rapidly incorporate new diagnostic information into the team's plans and processes. Subject matter experts concerned raised this issue that cognitive processes were not adequately represented. We therefore reviewed the diagnostic error literature, diagnostic decision-making literature, and team learning research to augment our model. The result is listed in Figure 1.

Figure 1.



This model reflects the cognitive and behavioral process components of trauma team performance. First, cognition is represented by the team's efforts to make sense of the situation (Situation Assessment). Briefly, the team must use existing data/observations to identify the patient- and team-related tasks and demands. This information is then used to develop a differential diagnosis. Based on this/these diagnoses, the team has

expectations regarding how the patient will respond to treatments and how his/her condition will evolve over time. The team continuously compares this “expected” state to the “observed” state of the patient. This comparison informs the team and helps regulate the team processes that regulate task performance. If the team notes a mismatch between expected patient improvement and current patient condition, this should prompt the team to review their plan, make adjustments, and execute the modified plan. The results of these new actions should be monitored and evaluated. The observations made during evaluation become the information that the team uses to reassess the situation, reconsider the differential diagnosis(es), and the adaptive cycle continues. In a rapidly evolving trauma resuscitation, this cycle repeats continuously to ensure the team is adapting to the unstable patient/team/environment.

Identifying appropriate training targets: Training should be purposeful and should target appropriate cognitive, behavioral, and affective/motivational processes in a stepwise fashion. Training mechanisms should support both skill implementation in the clinical environment as well as transfer to novel situations. We identified a staged approach to training that targets appropriate skills necessary to develop adaptive capacity. We include both individual and team-based processes as well as training mechanisms. The framework below (Figure 2) provides an outline for this approach.

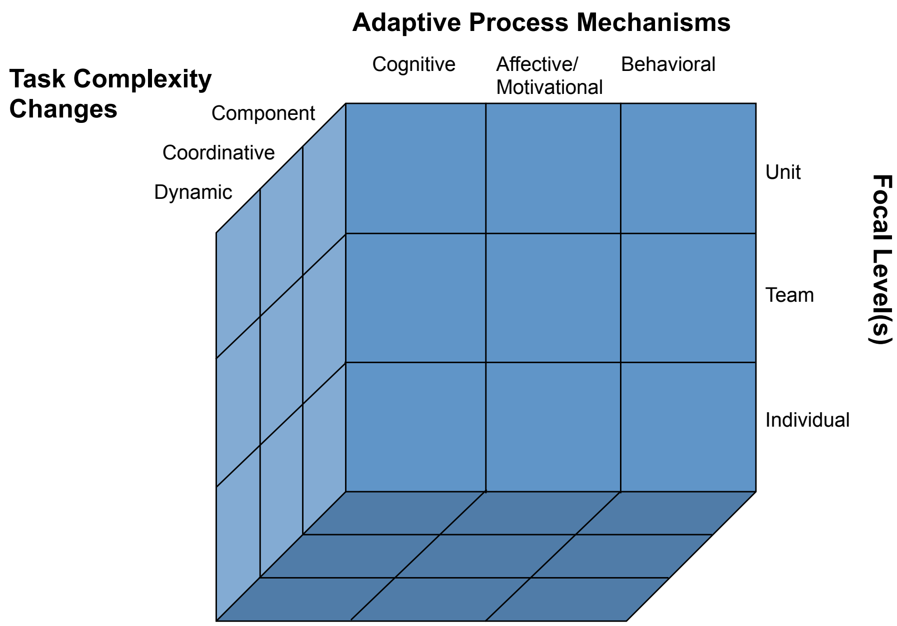
Figure 2. Training targets and training techniques

Basic **Knowledge and Skill Complexity** *Advanced*

	Instructional Goal			
	Declarative Knowledge/Skill	**Procedural Knowledge/Skill**	**Strategic Knowledge/Skill**	**Adaptive Knowledge/ Skill**
Targeted Knowledge/Skill	Facts, concepts, rules; Definitions, meaning (*What?*)	Task principles; Rule application (*How?*)	Task contingencies; selective application (*Where, when, why?*)	Generalization of task rules, principles, contingencies (*What now, what next?*)
Exemplar Task-based KSAs	Risk factors for ACS	ACLS algorithms ATLS algorithms	Treating undifferentiated shock	Contingency planning based on patient response to treatment
Exemplar Team-based KSAs	Team processes Shared cognition Leadership functions	Communication protocol Feedback/debriefing Conflict management	Resource management Consensus-building Problem definition	Situation awareness Task regulation Affect regulation
Instructional Delivery Technique	Memorization Static practice Consistent Automaticity			Experimentation Dynamic practice Variable mapping Controlled processing

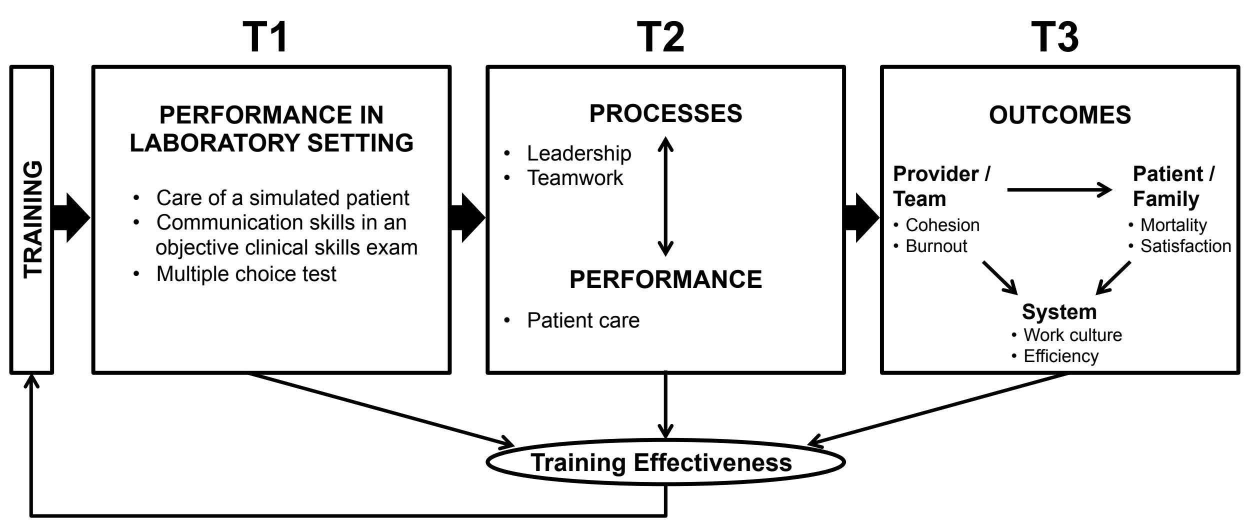
Identifying appropriate level of constructs and variables: A thorough understanding of individual and team performance within complex environments necessitates a multilevel approach to theory-building and outcomes research. Organization-level phenomena emerge through the behavior, perceptions, affect, and interactions of individuals and team. Likewise, individuals and teams are directly influenced by the culture, norms, and structure of the organization. Ignoring the multilevel nature of a construct, intervention, or relationship may result in oversimplification of outcomes and failure to recognize important measurement targets. We developed a multilevel conceptual architecture of adaptation that considers (1) the types of events teams must adapt to (i.e., what type of change is occurring), (2) the types of processes teams use to adapt, and (3) at what level these processes occur. This taxonomy (Figure 3) can help guide the selection of appropriate training targets and can help educators target correct task complexity, appropriate processes (cognitive/behavioral/affective), and direct training and measurement at the correct level (individual, team, unit). Such specificity is important, as being purposeful when designing training will ensure that individuals, teams, and units are prepared for the specific types of adaptation necessary for their work. This level of specificity in training is often overlooked and is not part of current training guidelines. In Appendix 1 we describe training principles related to (1) level of training and (2) specific processes targeted by training. In Appendix 2 we then describe three different task requirements for adaptability and specifically identify training principles associated with each type of task complexity.

Figure 3. Model of task complexity, processes, and level(s) of analysis



Identifying appropriate outcome measures and mechanisms: We noted that training evaluation systems should consider both proximal and distal outcomes. Proximal outcomes include both learning and performance-based outcomes and can include basic declarative knowledge as well as more complex strategic knowledge and performance. Distal outcomes that are trainee-focused include the transfer of learned skills to the work (clinical) environment as well as the application of learned skills to novel situations, i.e., adaptability. High-level distal outcomes include patient, system, and organization-level outcomes. Our literature review focused on the identification of pertinent proximal and distal outcomes. We considered our own systematic reviews as well as other health care team reviews to determine the current state of team assessment. We extended this knowledge by investigating the team science, safety science, and human factors literature. Because our work focuses on developing adaptive expertise, considerable efforts were made to identify outcome measures that reflect adaptive capacity. Subject matter expert review was utilized to help identify where non-health care team assessments can be translated into appropriate health care team training evaluation targets. In Figure 4 we propose a translational simulation-based research model that considers appropriate outcome measures and relationships for individual and team-level adaptability.

Figure 4. Multilevel outcome model for training evaluation



Recommendations for the provision of adaptive feedback: For the purposes of this work, we considered (1) performance measures used for the provision of feedback and (2) training evaluation/outcome metrics used to measure training impact, separately. The provision of feedback is a major focus of this study, with the goal of developing an assessment system capable of supporting embedded, adaptive guidance. We therefore directed our efforts towards developing a conceptual framework to support the content, structure, and provision of adaptive guidance during trauma team simulations. This work relied heavily on the training, education, and debriefing literatures. In Appendix 3 we list feedback principles, scientific rationale, and, where appropriate, exemplars for simulation-based training.

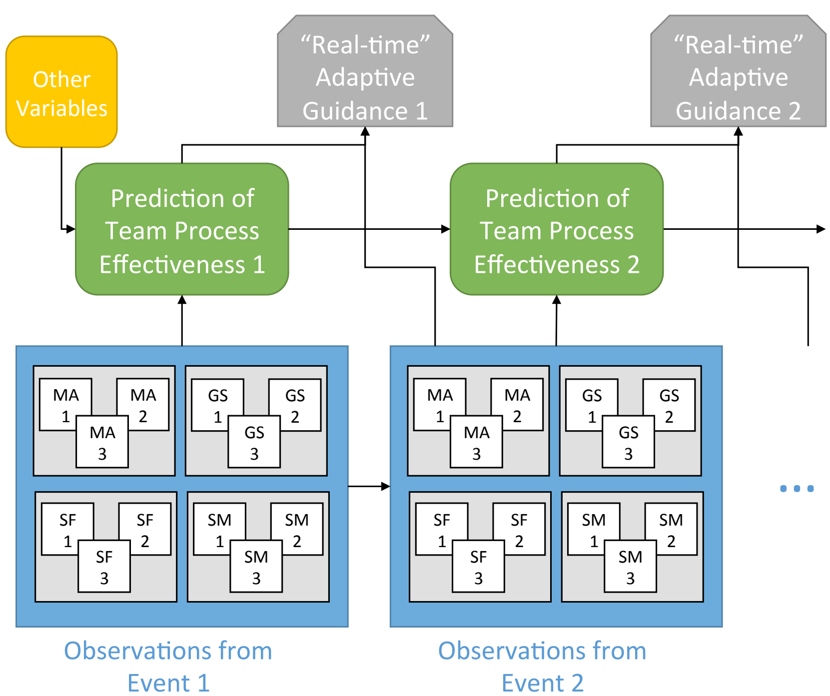
Deliverables: We plan a formal report of final recommendations and findings from Aims 1a & 1b to be disseminated no later than Q6. These results will comprise the material disseminated over the next year.

Aim 2. Develop and refine a predictive model of trauma team performance and outcomes for use in an adaptive guidance/feedback system

Trauma Simulations and Performance Coding: The purpose of conducting trauma team simulations is to provide baseline data for the design of the BBN. These simulations will be used, along with existing simulation data, to inform the structure of the BBN. Subject recruitment for prospective trauma simulations is completed, and the simulation sessions are underway. We have identified and recruited both civilian and military trauma team leaders. To ensure adequate military representation, simulations will continue until military trauma team leaders have completed the exercise. To date we have conducted 16 of the initially proposed 20 simulations and plan to extend this number to 22 to ensure adequate military representation. Simulation completion is slightly delayed but will be completed in Q5. As noted on our last report, we are able to make use of existing trauma simulations, which have been coded. Rater training will begin in the next quarter. New simulations will be coded on an ongoing basis throughout the next project year.

BBN Modeling: We explored several candidate approaches to BBN design. The preliminary approach determined to be most informative for the purposes of the project is provided in Figure 5. Briefly, this approach allows for the identification of critical feedback on key team processes (e.g., Mission Analysis [MA]; Goal Specification [GS]; Strategy Formulation [SF]; Systems Monitoring [SM]) at set points throughout the simulation. This type of feedback encourages individuals and teams to consider contingency planning and to actively evaluate their performance and make real-time adjustments as needed, i.e., adapt.

Figure 5. Proposed BBN approach



BBN Variables: We initiated review of existing datasets for candidate variables appropriate for inclusion in the BBN. Variables are considered appropriate if there is variability amongst subjects, and if variables correlate with overall performance and process as a whole. This requires evaluating over 100 process variables and 80 performance variables. With the input of subject matter experts, we are vetting the appropriateness of variables and are considering grouping certain variables into composite indicators for inclusion in the BBN. This would potentially simplify BBN input during testing and refinement. Finally, subject matter experts are considering variable states and relationships to ensure the BBN structure accurately reflects civilian and military trauma care. Candidate variables are listed in Appendix 4.

3c. What opportunities for training and professional development has the project provided?
Subjects enrolled in the study received simulation-based trauma team training and assessments. The simulation overview is provided in Appendix C as noted above. While the provision of training is not a major focus of this project, trainees were able to practice trauma management skills as well as leadership skills under difficult conditions requiring significant individual and team adaptation.

3d. How were the results disseminated to communities of interest?
Dissemination of our work from Aims 1a and 1b is planned for Q5 and Q6. Specifically, we are preparing two manuscripts, one describing our frameworks, training principles, and concepts related to adaptability and a second related to the provision of adaptive feedback. Adaptive feedback is a relatively new concept within medical simulation and one that needs to be considered within the growing literature around debriefing and the provision of performance-related information. We will also submit this work in the upcoming year to the Military Health System Research Symposium, the Annual Meeting for the Society for Academic Emergency Medicine, and the Annual Meeting for the Human Factors and Ergonomics Society. This will ensure wide distribution of information in military and civilian healthcare arenas as well as within the training and human factors community.

3e. What do you plan to do during the next reporting period to accomplish the goals?

Aim 1a. Develop a team training design architecture to support simulation-based training/assessment systems capable of developing adaptive expertise in health care teams
Aim 1b. Develop evidence-based guidelines and recommendations for the development of embedded, adaptive feedback and performance assessments

Integrate Conceptual Frameworks, Evidence-based Training and Assessment Mechanisms: Work for Aims 1a and 1b will focus primarily on integration of the models and dissemination. Using an approach outlined by Rousseau, et al. the investigators will integrate the information obtained in Steps 1 through 4 (individual- and team-level exogenous variables, critical teamwork processes and emergent states, multilevel relationships, and important proximal and distal outcome measurement targets) into a comprehensive team-training design architecture. We will use the literature review to identify knowledge gaps and immediate research targets. Specific attention will be given to important variables, implementation factors, and measures associated with the provision of embedded, adaptive guidance. The products of this work will be:

Deliverable 1. Health Care Team Training Design Architecture. A unified, evidence-based conceptual framework of health care team training effectiveness that identifies critical variables - individual and team factors, training design elements, and training implementation methods - that can be leveraged to improve team adaptive expertise and performance through robust simulation-based training systems
Deliverable 2. Embedded, Adaptive Guidance: Guidelines and Recommendations. Clear guidelines and recommendations for the design, development, and implementation of embedded, adaptive guidance to optimize team adaptability and team performance

These deliverables will be disseminated in two manuscripts. Manuscript preparation and submission is planned for Q5 and Q6 during project year 2.

Aim 2. Develop and refine a predictive model of trauma team performance and outcomes for use in an adaptive guidance/feedback system

Identification and Definition of Variables (Nodes) for Inclusion in Team Assessment Model: The first step in constructing any team assessment system involves defining the focal constructs of interest to be captured and specifying how they will be operationalized. However, assessment system designers must also recognize practical considerations (e.g., purpose of measurement, feasibility of implementation/use, etc.) when deciding what should be assessed and how observations will be captured. The investigators' are using their existing research and dataset to identify and extract variables/indicators that can be used to capture these

constructs. Subject matter experts in both team performance and health care practice have been recruited to review, supplement, and validate the final assessment targets. The result of this step will be identification of the directly observable measures and latent constructs that will be incorporated into the prototype BBN team assessment system. This work is currently in process and will be completed by Q6.

Designing the Structure for the Prototype BBN Team Assessment System: An important consideration when designing a BBN is adequate specification of the arcs and their probabilities. Depending on the goals of the predictive tool, a given set of nodes in a BBN may be linked together in different ways. Although these different configurations do not change the nature of the joint probability space modeled by the BBN, they do hold implications for how probability propagation occurs and inferences are drawn, which subsequently impacts how the model can be implemented in practice. Given the goals of the present project to leverage the predictive capabilities of BBNs as an assessment platform to facilitate real-time adaptive guidance, this step involves identifying appropriate and parsimonious candidates of the causal structure among the variables/indicators identified for inclusion in the model. The purpose of the prototype BBN model in this project is to serve as an assessment tool that could be used in a predictive fashion to facilitate adaptive guidance and expertise. As such, the complexity and precision of the influence network must be balanced so as to be both informative/evidence-based (i.e., critical relationships are modeled) yet feasible to implement real-time (i.e., minimally sufficient number of indicators to monitor). The investigators will once again rely on multiple resources to inform these decisions. The final result of this step will be identification of multiple candidate BBNs for the observed variables that could serve as potential predictive assessment models in the present learning environment.

Generation of Initial Probability Tables for BBN Team Assessment System: The computational "engine" and predictive validity of a BBN relies on the presence of well-informed conditional probability tables (CPTs). A CPT exists for every node in a BBN and reflects the probability that a particular state for a particular node will be observed given the state of all its parent nodes (e.g., *p*(*Chest Compression Quality* = High | *Assign a Team Leader* = No), etc.). In this sense, CPTs represent the degree of interdependency (i.e., correlation) that exists between variables that share a directed arc. To compute the CPTs for the candidate networks, the investigators will utilize their existing dataset to "train" a set of initial conditional probabilities for the modeled variables. This process will entail several steps. First, data must be transformed into an appropriate categorical structure that can be interpreted by a BBN. Next, different learning algorithms will be explored (i.e., counting, expectation-maximization, gradient descent) in an attempt to produce the "maximum likelihood BBN," or the set of CPTs that is most likely given the observed data. The fit of the algorithms will be assessed using standard model evaluation techniques (e.g., confusion matrix, times surprised, etc.); additionally, these metrics will be used to compare candidate BBNs to identify the best fitting model. Finally, in instances where data is unavailable or insufficient to generate a suitable CPT, existing empirical literature (i.e., meta-analyses) and/or subject matter experts will be relied upon to generate the nature of the conditional dependence. The result of this step will be development of the best fitting, functional prototype BBN team assessment system based on existing data.

BBN Team Assessment System Calibration: A potential concern with using only a single sample to construct a BBN is that the model and its accompanying CPTs may be "overfit" and fail to generalize beyond the training data. Thus, in the final step of development, the performance of the BBN team assessment system will be evaluated and recalibrated using the new data collected through coding of simulations. A similar approach to evaluating model fit as described above will be implemented to examine the adequacy of the BBN's predictions in the new data. To the extent that misfits among particular nodes or relationships are identified, the investigators will rely on subject matter experts and empirical evidence from the literature to identify whether and/or how to adapt the BBN (adjust CPTs, specify new nodes/variables, revise causal pathways). Irrespective of fit, the new data can be used to improve the precision of the BBN assessment model through added observations. The results of this step will thus be improvement and calibration of the prototype BBN team assessment system.

4. Impact for Project Year 1 Work

4a. What was the impact on the development of the principal discipline(s) of the project?

Our work will improve training, maximize healthcare provider performance, and minimize morbidity for our injured service men and women. Once disseminated, the work from project year one will provide military and civilian healthcare providers and educators with clear guidelines for the development of training that builds adaptive capacity. Specifically, we provide developmentally appropriate training targets for individuals and teams. We identify what training content and delivery method is most appropriate for developing adaptive behaviors around certain types of tasks. We recognize that frontline medics adapt to different situations than physicians in specialty clinics and our guidelines account for these differences. We aim to provide a clear, easily applied method to help educators and trainers make decisions regarding training development and implementation. Our work will facilitate the development of longitudinal curricula across multiple specialties and disciplines by providing clear training targets for individuals and teams at all levels of performance.

The guidelines and principles for adaptive feedback introduce a new and important concept to healthcare. The provision of "feedback" and "debriefing" in experiential training has been identified as critical to learning. However, the role for adaptive feedback in the development of highly adaptive teams has not been described. We will disseminate our review of the topic along with specific recommendations for implementation within simulation-based training. Along with the work to be performed in Aim 2, this information will provide the foundation for the development of simulation-based training with automated, adaptive feedback.

4b. What was the impact on other disciplines

Our work has impact beyond healthcare. We highlight the challenges associated with training and evaluating performance in complex environments. This information is useful in human factors and organizational psychology, where teamwork has often been considered a static construct, rather than a dynamic entity where teams learn, adapt, and react to continuous changes in the task, environment, and team. Our framework highlights how important it is to consider characteristics of the task(s) necessitating adaptation when developing training programs. This work provides a foundation to build more comprehensive training that goes beyond TeamSTEPPS-type training to impact complex teams performing in highly dynamic, potentially dangerous situations.

4c. What was the impact on technology transfer?

Nothing to report

4d. What was the impact on society beyond science and technology?

Failure to adapt to rapidly changing conditions is a primary cause of medical error. In military settings, such failures can also lead to significant harm to providers. Our work has a significant impact on patient safety, decreasing soldier morbidity and mortality, and on patient satisfaction. Simulation is a key modality leveraged by the military to advance expertise and ensure that soldiers receive the highest level of clinical care. Significant human and technological resources are dedicated to developing and implementing rigorously tested, high-quality simulation-based curricula. Clear guidelines and a training framework focused on developing adaptive capacity did not exist. We fill this gap and, in doing so, provide an important mechanism to support the development and implementation of highly effective individual and team-level healthcare training.

5. Changes / Problems

5a. Changes in approach and reasons for change

None

5b. Actual or anticipated problems or delays and actions or plans to resolve them

Scheduling the simulations was slightly delayed due to the residents' (subject) clinical schedules. Simulations are now underway. To ensure adequate military representation, we will continue executing simulations through the beginning of PY2 to obtain sufficient military subject data. We do not anticipate any additional delays.

We anticipated completing simulation coding at the end of the first project year. This work was slightly delayed due to the need to train new coders. To assist with this work, the graduate student (Santoro) at Michigan State University will be focusing on monitoring and re-training coders as needed. This will also assist with the additional work associated with coding additional simulations planned for the study. We anticipate this will address the problem and will do so without impacting our budget. Ms. Santoro will remain on the project until its completion. Additionally, we are hiring a second research coordinator (0.5 FTE) to assist with both simulations and, more importantly, formatting coded performance data to ensure it can be quickly used for the BBN work in Aim 2. We had hoped to have this individual identified at this point. S/he will start on January 1 and a CV will be forwarded when available.

In summary, we have experienced slight but manageable delays that will not impact the completion of the project within the proposed budget. Our solutions are in process and we anticipate no new issues.

5c. Changes that had a significant impact on expenditures

The project is currently on budget. Delays in hiring the research assistant and delay in starting simulations have shifted some of the costs from project year 1 to project year 2. Subcontract costs are encumbered now for years 1 and 2. The slight delays described above do not impact the budget, and we fully anticipate completing the project within the proposed budget.

5d. Significant changes in use or care of human subjects, vertebrate animals, biohazards, and/or select agents

None. While we increased our enrollment to 22 teams, this protocol is exempt and no further action is needed.

6. Products

6a. Publications, conference papers, and presentations

Fernandez R, Rosenman ER; Santoro J, Pacic E, Golden SJ, Brolliar SM, Chao GT, Grand JA, Kozlowski SWJ. A multicenter, observational study of teamwork, team cognition, and leadership. *2016 Military Health System Research Symposium*, Orlando, FL.

6b. Website or other Internet sites

None

6c. Technologies or techniques

None

6d. Inventions, patent applications, and/or licenses

None

6e. Other products

None

7. Participants & Other Collaborating Organizations

7a. What individuals have worked on the project?

Name:	Rosemarie Fernandez, MD
Project role:	Principal Investigator
era Commons ID:	av9546
Nearest person month worked:	2 cal.months (0.2 FTE)
Contribution to project:	Worked with ER to review actual trauma resuscitations and identify missing components of the conceptual framework. Worked with JG, ER, GC to modify the conceptual framework to include a cognitive component. Recruited subjects for simulation and began simulation implementation.

Name:	James Grand, PhD
Project role:	Co-Principal Investigator
era Commons ID:	Grandjam
Nearest person month worked:	3 cal. Months (0.25 FTE)
Contribution to project:	Worked with GC to conduct team science component of literature review. Worked with RF, ER, GC to modify conceptual framework. Identified team science-related training principles and recommendations.

Name:	Elizabeth Rosenman, MD
Project role:	Co-Investigator
Nearest person month worked:	2 cal. Months (0.2 FTE)
Contribution to project:	Worked with RF to review actual trauma resuscitations and identify missing components of the conceptual framework. Worked with JG, RF, GC to modify the conceptual framework to include a cognitive component. Recruited subjects and began simulation implementation.

Name:	Georgia Chao, PhD
Project role:	Co-Investigator
Nearest person month worked:	2 cal. Months (0.19 FTE)
Contribution to project:	Worked with JG to conduct team science component of literature review. Worked with RF, ER, JG to modify conceptual framework. Identified team science-related training principles and recommendations.

Name:	Karlee Jackson, BA
Project role:	Research assistant
Nearest person month worked:	6 cal. Months (0.5 FTE)
Contribution to project:	Coordinated subject recruitment, worked with simulation center to schedule and execute simulations. Trained all confederate roles to ensure consistency in simulation execution. Worked with investigators to develop data storage solution.

Name:	Benjamin Levine, BA
Project role:	Graduate student research assistant
Nearest person month worked:	6 cal. Months (0.5 FTE)
Contribution to project:	Performed literature review, assisted with framework development and revision. Worked with team to develop BBN approach and is leading evaluation of potential variables for model inclusion.

Name:	Jessica Santoro, MA
Project role:	Graduate student research assistant
Nearest person month worked:	1 cal. Months (will be at 0.5 FTE for upcoming project year)
Contribution to project:	Assisted with development of adaptive feedback principles, performed related literature review, will be assisting with rater evaluation and retraining as needed.

7b. Has there been a change in the active other support of the PD/PIs or senior/key personnel since the last reporting period?

Ms. Santoro began in her role as the graduate student at our collaborating site, Michigan State University. Ms. Santoro assisted with the large literature search for Aim 1 and will have a significant role assisting with rater evaluation and training throughout the project.

As we noted in our last report, we are hiring an individual to assist with research assistant tasks. This person's hire was slightly delayed, and we anticipate them starting in the next quarter. This will help to facilitate the remainder of the simulations and performance coding.

We intend to add CPT. Lindsay K. Grubish, DO to the project, as Dr. Jay Baker took a new position and is no longer able to assist with the project. CPT. Grubish is a staff physician in the Department of Emergency Medicine at MAMC. She has experience using simulation to assess performance in military medical providers under stress. She will be responsible for providing subject matter expertise and recruitment of military residents for the simulations. We are in the process of obtaining appropriate letters of support and will provide a CV and copy of letters when available.

7c. What other organizations were involved as partners?

University of Maryland
Department of Psychology
College Park, Maryland
The Co-PI, Dr. Grand, and a graduate student, Mr. Benjamin Levine, are both supported at the University of Maryland. There, they have office space, computer access, and support for virtual meetings with the research team.

Eli Broad College of Business / Michigan State University
East Lansing, Michigan
Dr. Chao (collaborator) and a graduate student, Ms. Jessica Santoro, are both supported at Michigan State University. There, they have office space, computer access, and support for virtual meetings with the research team.

8. Special Reporting Requirements

8a. Collaborative Awards
N/A

8b. Quad Chart
Please see Appendix 5 for updated Quad Chart.

APPENDICES

Appendix 1. Training principles to target adaptive processes at different levels.

Principle and Applicable Level(s)	Rationale	Simulation application
Use advance organizers at the start of training. (Individual Level)	Advance organizers are materials presented at the start of training that provide an initial organizing structure of the subject matter discussed in training. Advance organizers are used to organize conceptual information and foster connections between similar ideas as well as delineate different concepts from one another. Trainees who use or develop their own advance organizers are more likely adaptively transfer knowledge and skills than those who did not use or develop advance organizers.	• Inform trainees about training focus. This does not necessarily mean informing them of key critical content planned for simulations; rather, tell trainees they will be focusing on team (or individual) skills • Suggest that trainees consider personal strengths and weaknesses prior to coming to training.
Promote trainees to have a learning goal orientation during training. (Individual and Team Level)	Training design that promotes a learning goal orientation (e.g., a focus on self-improvement and task mastery in achievement situations) has been linked to positive training outcomes, such as goal setting, self-regulatory activities, learning, and performance. This is in stark contrast to promoting a performance goal orientation (e.g., a focus on demonstrating ability to others in achievement situations) which has been shown to negatively relate to goal striving processes and performance.	• Promote a learning goal orientation by encouraging trainees to set goals about achieving learning objectives and acquiring relevant knowledge and skills. • Establish psychological safety
Trainees should be provided with strategy instruction later in training once appropriate foundational knowledge has been developed. (Individual)	The KSAs required to effectively engage in individual and team adaptation are advanced learning outcomes. Without achieving proficiency in the basic and procedural knowledge necessary to carry out core task/job requirements in a domain, efforts to improve the adaptation process will be less effective.	• Assess individuals for team-based simulation "readiness" • Use low fidelity non-clinical simulations to begin building team skills while individuals are still developing clinical knowledge. • At this stage, interdisciplinary training is not important; however institutions should ensure consistency of curriculum across professions/units/schools
Training material should be structured so that instruction proceeds from general to detailed, specific to complex. (Individual and Team Level)	Successful team adaptation requires integrating, coordinating, and regulating a variety of different KSAs, resources, and members. Developing the capacities to manage these processes should be scaffolded to allow learners to first build basic competencies and then practice/engage in more complex applications. Note that this also applies to actively training members as part of intact teams -- team-based training designed to enhance adaptability is a complex environment and should be postponed until learners have engaged in more foundational training exercises.	• Team-based simulations should initially use basic clinical scenarios rather than unusual or highly complex situations. Once basic team skills have transferred from "non-clinical" simulations (above) to straightforward clinical issues, more complex team and environmental issues can be added. • Use EBAT to create a simulation experience where modules can be added to model more complexity as well as to target specific team skills.

Trainees learning a complex task should be encouraged to monitor rate of learning progress rather than just learning performance. (Individual Level)	Training that emphasizes learning trajectories, development, and velocity is more likely to minimize goal abandonment, promote self-efficacy, and encourage trainees to view training as "learning" rather than "evaluation." Additionally, emphasizing "future-focused" cognitive appraisals (i.e., focusing on how learning outcomes/capabilities are evolving) reinforces the cognitive appraisal frames critical to team adaptation.	• During pre-brief, make it clear to learners that there may be no "right answer". • Establish a learning environment that supports psychological safety. • If using a modular EBAT approach, consider guiding teams to recognize how similar problems were addressed in the past so they can monitor their progress.
Trainees learning complex tasks should be provided with proximal subgoals that break the task into smaller parts. (Individual and Team Level)	Team adaptation is a process characterized by an ongoing cycle of situation assessment and team/task management. The KSAs which underlie successfully execution of these stages can be developed through "part-learning" and by breaking the adaptation process into meaningful chunks. This approach is more likely to increase learner self-efficacy and persistence, and allow practice opportunities & feedback to be tailored towards more focused learning objectives.	• Break down adaptive behaviors into clear activities that can be practiced in isolation. If necessary, remove learners from the clinical setting to work on key activities prior to re-entering a high-fidelity simulation.
Trainees presented with extremely difficult problems that appear unsolvable should be assisted in making some consistent progress during training. (Individual Level)	The structure of the training environment and practice opportunities for team adaptability should not be "sink or swim" (esp. during initial stages of practice). Feedback and direction that actively guides teams through how to think through a complex task and make decisions about resources is a critical foundation of team adaptability training. Providing guidance that prompts teams to explore options for task completion during training helps to avoid discouragement, anxiety, and abandonment of effort.	• Use triggers and backup triggers during simulations to allow learners to attempt the behavior and, if unsuccessful, observe an "expert" (confederate) execute the behavior with success. • Junior learners that may lack clinical knowledge should be encouraged to seek assistance for help at any time. Using confederates as "mentors" can not only assist learners through difficult tasks but also will build comfort with seeking help from other team members and those outside the team.
Variability in practice trials should be provided during training to maximize retention & transfer. (Individual and Team Level)	Whereas early stages of training are enhanced by repetition and rehearsal (i.e., developing declarative & procedural knowledge), advanced stages of training are enhanced by exposing trainees to as diverse an array of scenarios in which to apply their KSAs as possible. It is particularly critical to expose trainees to situations where previously learned, frequently used, and/or typically reliable courses of action are ineffective. Providing variability in practice trials promotes the development of broader associative knowledge structures and contingency-based thinking.	• Use EBAT to build simulations that contain appropriate task complexity • Shorten intervals between prompts to increase time pressures as appropriate. • Use confederates to add interpersonal challenges. • Build in environmental challenges (e.g., additional patients, equipment failure) to increase complexity
Training should be permissive of, embrace, and even encourage errors made by learners during training. (Individual and Team Level)	Errors are an inevitable component of real-world performance. Errorless training leads to effective training performance, but is often related to poor training transfer. Although errors during training should be brought to learners' attention, learning that is focused on error management as opposed to error prevention is more successful. Framing training as an opportunity to make and learn from errors encourages trainees to develop problem-solving or hypothesis-testing skills and strategies for managing affective responses (e.g., frustration and anxiety).	• Use confederates to “force” errors during simulations. This requires considerable expertise in debriefing to ensure learners do not feel “tricked”. Appropriate pre-briefing and establishment of a learning environment can help. Be sure that “errors” meet a minimum level of psychological fidelity for learners.

Incorporate lessons on how to alter coordination strategies in training. (Team Level)	When task demands are low, trainees should learn to discuss possible problems that could arise later in the task. By discussing their coordination strategies during this period, they will likely reduce the amount of communication necessary to achieve successful team performance later and allow them to be adaptive when novel problems arise in the environment.	• Encourage learners to develop contingency plans • Discuss team member understanding and mental model development during debriefing to help reinforce the importance of discussing and practicing team coordination
Integrate metacognitive prompts into training. (Individual Level)	Metacognition is the process of actively reflecting on one's thought processes. Encouraging metacognitive activity during training can help learners identify and focus on the goals, assumptions, and strategies guiding their decision-making and task performance. This is especially important for less experienced trainees learning to perform in complex and dynamic environments and who may struggle with such "big picture" thinking.	• Employ "think aloud" protocols during simulation-based training in which the trainee verbalizes their thought process during practice • Build in opportunities for more frequent huddles during simulation-based training in which the trainee is prompted to explicitly discuss their rationale for previous decisions and considerations for future plans.

Appendix 2. Identifying Task Complexity and Associated Best Practice Training Principles

Adapting to changes in Component complexity Changes in number and/or difficulty of tasks		**Adapting to changes in Coordinative complexity** Changes in sequencing, prioritization, & interdependence among tasks		**Adapting to changes in Dynamic complexity** Volatility in component & coordinative complexity within a task	
Principle	**Rationale**	**Principle**	**Rationale**	**Principle**	**Rationale**
Trainees should not be provided strategy instruction until later in training	Emphasizing "chunking" and how to complete small numbers of simple, manageable tasks during early knowledge/skill acquisition promotes self-efficacy and draws focus away from premature comparative & normative evaluations	Trainees should not be provided strategy instruction until later in training	Shifting training towards prioritization, how to develop contingencies, and managing distal vs. proximal goals once trainees have achieved proficiency in basic knowledge and skill promotes mastery learning and promotes "big picture" thinking	Trainees should not be provided strategy instruction until later in training	Shifting training towards recognizing when change is needed and when/how to implement contingencies focuses trainees appropriately on normative expectations and being proactive.
Training material should be structured so that instruction proceeds from general to detailed, specific to complex	Scaffolding practice such that trainees learn to deal with few/simple tasks --> more/simple tasks --> few/difficult tasks --> more/difficult tasks enables training/feedback to focus on quantity vs. complexity of tasks, which pose different considerations	Training material should be structured so that instruction proceeds from general to detailed, specific to complex	Scaffolding practice such that trainees learn to deal with few/simple tasks --> more/simple tasks --> few/difficult tasks --> more/difficult tasks enables training/feedback to focus on quantity vs. complexity of tasks, which pose different considerations	Training material should be structured so that instruction proceeds from general to detailed, specific to complex	Training that allows practice shifting from few/simple tasks to more/complex tasks *within the learning environment* allows learners to practice situation assessment and task regulation cycles under different demands
Trainees learning a complex task should be encouraged to monitor rate of learning progress rather than just learning performance	Focusing feedback on how and what KSAs trainees have developed that **involve managing different quantities of tasks** minimizes goal abandonment and promotes learning how to deal with situations where resources (time, persons, etc.) are strained	Trainees learning a complex task should be encouraged to monitor rate of learning progress rather than just learning performance	Focusing feedback on how and what KSAs trainees have developed that **involve managing tasks with fewer vs. more interdependencies and considerations** minimizes goal abandonment and promotes learning how to deal with situations where resources must be highly coordinated	Trainees learning a complex task should be encouraged to monitor rate of learning progress rather than just learning performance	Focusing feedback on how and what KSAs trainees have developed that are **involve managing sudden changes in task demands** minimizes goal abandonment and promotes learning how to deal with situations where resources must be quickly assessed, gathered, and distributed
Provide & emphasize proximal subgoals that allows trainees to break task down into manageable components	Focusing on how to deal with multiple competing demands and strained resources improves capacity to manage tasks where demands >= supply	Provide & emphasize proximal subgoals that allows trainees to break task down into manageable components	Focusing on how to prioritize and structure task activity improves capacity to make informed decisions & communicate what must be accomplished to reach task goals	Provide & emphasize proximal subgoals that allows trainees to break task down into manageable components	Focusing on how to deal with variability in task demands/resources within a single performance event improves capacity to shape and implement contingencies

<u>Adapting to changes in Component complexity</u> Changes in number and/or difficulty of tasks		**<u>Adapting to changes in Coordinative complexity</u>** Changes in sequencing, prioritization, & interdependence among tasks		**<u>Adapting to changes in Dynamic complexity</u>** Volatility in component & coordinative complexity within a task	
Principle	**Rationale**	**Principle**	**Rationale**	**Principle**	**Rationale**
Variability in practice trials should be provided during training to maximize retention & transfer	Practicing multiple situations with fewer/simple, fewer/difficult, more/simple, more/difficult exposes trainees to more exemplars, prepares them for more situations, and encourages flexible modes of thinking/problem-solving	Variability in practice trials should be provided during training to maximize retention & transfer	Practicing multiple situations with fewer/simple, fewer/difficult, more/simple, more/difficult exposes trainees to more exemplars, prepares them for more situations, and encourages flexible modes of thinking/problem-solving	Variability in practice trials should be provided during training to maximize retention & transfer	Practicing situations that transition from fewer/simple, fewer/difficult, more/simple, more/difficult *within the learning environment* exposes trainees to more exemplars, prepares them for more situations, and encourages flexible modes of thinking/problem-solving
Trainees should be encouraged to experience errors	Errors of omission & commission are common stimulus for adaptation. Placing trainees in situations where few vs. many, little vs. big, salient vs. subtle, etc. errors are likely and/or have happened reinforces situation awareness and decision-making skills in unexpected and unplanned situations	Trainees should be encouraged to experience errors	Errors of omission commission are common stimuli for adaptation. Placing trainees in situations where errors push them down a wrong path reinforces situation awareness and decision-making skills in unexpected and unplanned situations	Trainees should be encouraged to experience errors	Errors of omission & commission are common stimuli for adaptation. Placing trainees in situations where tasks change suddenly and errors are more likely reinforces situation awareness and decision-making skills in unexpected and unplanned situations

Appendix 3. Principles of providing adaptive feedback

Principle 1. Trainees should be provided with accurate and credible feedback.
Ensuring feedback is accurate helps trainees understand what task behaviors need improvement. Making feedback credible/authentic improves the likelihood that trainees perceive the feedback as something important to which they should attend. There are instances in which the accuracy of feedback should be "altered" if it benefits self-efficacy and effort of trainees (e.g., learning a complex task that results in many mistakes, poor training performance, etc.).
Simulation Recommendations:
- Explain learning objectives to trainees and explain clear benchmarks for performance. By setting benchmarks, trainees can see where their performance gaps lie. Setting benchmarks also helps ensure feedback is diagnostic.
- The feedback facilitator should have significant skill in debriefing techniques.
- Consider pairing a content expert with feedback expert when needed

Principle 2. The frequency and timing of feedback should be appropriately tailored to trainees and the goal of training.
In general, directive, immediate, and frequent feedback tends to facilitate the acquisition of declarative & procedural knowledge and improve learner's self-efficacy. However, when the goal of training is to promote how to identify and handle errors and/or develop strategies and contingency-based thinking, feedback should be less frequent to discourage trainees from assuming there is "one correct answer" they should be learning.
Simulation Recommendations:
- Process feedback should be more frequent than outcome feedback
- With more experienced teams, moving from a formalized feedback to facilitation of a high-level debrief that allows objectives to emerge based on performance and team challenges might be more appropriate
- When performing a more high-level debrief, it should occur as close to the event as possible
- Be sure to build in adequate time for debriefs, usually a minimum of 2x the length of the simulation
- Ensure that the simulation objectives are finite and can be covered during the debrief

Principle 3. Feedback related to practice behaviors and strategy development should be specific.
When it is appropriate to provide such feedback (see principle above), feedback about the behaviors in which trainees engaged; how, why, and what strategies trainees attempted to implement; and the manner by which they addressed errors or unexpected events should be specific and detailed. Providing specific feedback facilitates the retention and automatizing of learned material and helps to avoid ineffective strategy or behavioral changes.
Simulation Recommendations:
- Ensure that team members have a working knowledge of team processes prior to executing the simulation; this will allow the facilitator to use this common language during the debrief
- Refer to specific examples during the simulation to highlight strengths and weaknesses of team process.
- Video review may be helpful
- Providing individuals with feedback is important; however, must be done with care in a team debrief
- Using self-assessment "cognitive aids" can help individuals assess their contribution to team performance.

Principle 4. Feedback should be more heavily focused towards process rather than outcome.
Outcome feedback conveys the extent to which trainees met/are meeting learning objectives. Alternatively, process feedback focuses on how trainees are using information, performing behaviors, and the steps used to complete task activities. Process feedback directs learners to reflect on the strategies and decisions that led to particular outcomes, and is thus particularly important when the goal of training is to improve regulatory/strategic thinking.
Simulation Recommendations:
- Allow teams to discuss medical content and address any concerns quickly to help learners focus on processes of care
- Encourage learners to consider other circumstances where similar processes are employed and can fail. This helps team focus on processes instead of the specific clinical issues presented in the simulation.

Principle 5. Trainees should be encouraged to believe substantial negative performance discrepancies are moderate.

Acquiring KSAs in complex task environments is challenging, and learners are not likely to perform well during initial stages of training. Providing accurate and credible feedback is important, but it is equally critical to ensure that trainees do not become overwhelmed and/or discouraged by actions they have performed incorrectly. This balance can be achieved by framing feedback such that: (1) feedback emphasizes trainee performance is attributable to controllable factors; (2) feedback de-emphasizes outcome-focused feedback in favor of process feedback and feedback that highlights how learners are developing; (3) initially poor performance be labeled as only moderately negative. Doing so decreases the likelihood of goal abandonment while increasing the likelihood that effort and self-efficacy will be maintained.

Simulation Recommendations:

- Encourage learners to note positive as well as negative behaviors (What should you change? What should you do the same?)
- Encourage learners to see how even effective processes can result in poor outcomes
- Limit the focus of the debrief to just learning objectives to avoid talking about too many issues
- Focus on process, not outcomes

Principle 6. The provision of negative and/or normative feedback should be minimized to trainees learning a complex task.

Negative feedback (i.e., learners are failing to meet learning objectives) and normative feedback (i.e., comparing learners to an external standard) tends to shift trainees' attributions towards the self & ego protection, which generally interferes with the acquisition of KSAs. Negative feedback--especially when learning a complex task--is demotivating and tends to decrease self-efficacy. In general, positive performance feedback tends to improve self-efficacy, though it must be accurate and credible to prevent complacency and/or disengagement.

Simulation Recommendations:

- Provide a supportive climate that allows participants to share opinions openly and honestly
- Critical step, as learners cite a fear of educator and peer judgment as barrier
- Use "good judgment" framework or advocacy/inquiry to discuss negative performance and uncover learner mental models and frames that are supporting suboptimal performance

Principle 7. Guidance that directs trainees to consider what they should think about and how to think about it should be provided to trainees in learner control environments.

Guidance is a proactive "feed-forward" mechanism that encourages learners to take an active role in considering how and why they are engaging in particular learning behaviors. Guidance promotes learning through both increased metacognition (i.e., "thinking about thinking") and encouraging an exploratory/future-focused perspective on learning--both of which are critical conditions for learning complex tasks and strategies. There are many options for what type of guidance can be provided, but typical categories include focusing trainees on how and where to direct attention during training (cognition), manage effort and emotions (affect), and sequence actions (behaviors).

Simulation Recommendation:

- Learners should be encouraged to identify their strengths and weaknesses. With instructor input, this information should be used to guide training content and emphasis. In this way, learners can focus on more basic skills where they need development and challenge themselves in areas where they excel.
- Guidance can also come in the form of affect/error regulation that emphasizes to learners that good processes don't always result in good outcomes.

Principle 8. Match the level of feedback provided to the level of the goals in training.

Feedback provided in training directs individuals to allocate resources and perform self-regulation activities in relation to specific goals. However, trainees can have goals across multiple levels thereby complicating trainees' decisions about which goals to strive toward. Therefore, if the focus of training is to achieve individual-level goals, feedback providers should provide individual-level feedback so resources are directed to individual goal attainment. Similarly, if trainees should focus on team-level goals, feedback providers should provide team-level feedback to direct resources toward team goal attainment.

Simulation Recommendations:
- The debriefing plan should be pre-planned and should target appropriate level(s) based upon learning objectives.
- When individual feedback is necessary within a team context, the learner should be approached separately if there is an issue with individual clinical competence or procedural skills.
- If individual feedback on a team skill is necessary, feedback should be framed as a team-based learning point.

Appendix 4. Examples of candidate variables for the BBN model

Examples of candidate team process variables for BBN model

Process	Item	Activity
MA	Nurse is questioned to gather additional information (e.g., “Did the EMS leave a run sheet?”)	Evaluation
MA	Reason for patient admittance is communicated	Evaluation
MA	Pre-hospital vital signs are communicated	Evaluation
GS	Request for updated/new vital signs is given (versus pre-hospital vitals)	Evaluation
MA	Updated vital signs are communicated to team	Evaluation
GS	Pulse checked on arm or neck of patient	Evaluation
GS	Pulse checked in feet	Evaluation
GS	Breathing checked by listening to chest with stethoscope	Evaluation
MA	Results of lung exam are communicated (e.g., “breathing is labored”)	Evaluation
GS	Gag reflex checked	Evaluation
GS	Attempts to elicit speech by talking to patient	Evaluation
GS	Chest wall is assessed by palpation	Evaluation
MA	Glasgow coma scale (GCS) is communicated (e.g., “GCS is XXX”)	Evaluation
MA	Abdomen is assessed	Evaluation
TM/BB	Blood pressure is monitored and communicated during intubation	Airway management
SM	ET tube placement is verified by listening to patient’s chest	Airway management
MA	Team discusses cause(s) of hypotension	Injury management
SM	Team members monitor blood pressure during blood transfusion	Injury management

Examples of candidate team performance variables for BBN model

Performance	Category	Item
Diagnosis	Cardiac monitor interpretation	HR is verbalized
		Rhythm is assessed to be “tachycardia”
	GCS	Correctly calculated
Evaluation	Radiographs Ordered	Time CXR ordered
		Time Head CT ordered
		Time Pelvis X Ray ordered
		Time FAST or USN ordered
Airway management	Intubation	Length of intubation (time)
		Time decision made to intubate
		Bagging rate immediately following intubation

Development of an Integrated Team Training Design and Assessment Architecture to Support Adaptability in Healthcare Teams

MSIS-Team Performance Training Research Initiative

PI: R. Fernandez / J. Grand **Org:** University of Washington

DMRDP

Problem, Rationale, and Military Relevance

- **Problem:** Conceptual models and assessment approaches to support effective team training that maximizes team adaptability and performance do not exist.
- **Rationale:** An integrated team training model will identify ***which*** individual, team, and training design factors can be manipulated to maximize team training effectiveness and impact on patient safety outcomes. Additionally, a predictive model of team performance will demonstrate ***how*** team behaviors predict future team performance and patient care outcomes.
- **Military Relevance:** This proposal directly addresses the TPT research initiative by providing a detailed framework and predictive assessment system to support team performance training to improve teamwork behaviors and patient outcomes.

Conceptual Model of Team Training Elements + **Predictive Model of Team Performance**

OPTIMIZED TRAINING

IMPROVED ADAPTABILITY AND PATIENT SAFETY

Proposed Solution

- **Objective:** To develop a simulation design architecture and predictive model of trauma team performance to support team training and team effectiveness.
- **Summary of Aims:** Integrate individual- and team-level team performance frameworks to develop a simulation design architecture and a predictive model of trauma team performance to support effective team training with automated individual and team feedback and performance assessment.
- **Outcomes:** (1) A detailed framework of the individual, team, and training design factors related to effective team performance training and (2) A predictive model of team performance that identifies how teams can adapt their behaviors to maximize their teamwork and minimize errors

Timeline and Cost

Activities FY	15	16
Integrate individual-level and team-level simulation design frameworks to develop a simulation design architecture (Aim 1)		
Develop a predictive model of trauma team performance and outcomes using Bayesian Belief Networks (Aim 2)		
Prospectively test and refine the model of trauma team performance on simulated trauma team resuscitations (Aim 2)		
Data analysis and dissemination		
Estimated Budget ($K)	591K	556K